REMARKS

I. Introduction

By the present Amendment, claims 6 and 7 have been amended. No claims have been added or cancelled. Accordingly, claims 6-12 remain pending in the application. Claim 6 is independent.

II. Interview

Applicants would like to thank Examiners Brutus and Chen for the courtesy and cooperation extended during the interview conducted on January 11, 2011. During the interview, Applicants discussed proposed amendments to better clarify the output of the amplifier and sampling rate. Applicants further indicated that the cited reference was silent on controlling the sampling frequency as set forth in the claimed invention. The Examiner indicated that the proposed amendments did not appear to be properly supported in the specification. Applicants further indicated that materials would be obtained to support these features.

III. Office Action Summary

In the Office Action of September 13, 2010, claim 6 was rejected under 35 USC §112, second paragraph as being indefinite. Claims 6-12 were rejected under 35 USC §103(a) as being unpatentable over U.S. Patent No. 5,833,614 issued to Dodd et al. ("Dodd") in view of Wilkening (Phase-coded Pulse Sequence for non-Linear Imaging), and further in view of U.S. Patent No. 6,497,665 issued to Hunt et al. ("Hunt"). This rejection is respectfully traversed.

IV. Rejection under 35 USC §112

Claim 6 was rejected under 35 USC §112, second paragraph as being indefinite for failing to particularly point out and distinctly claim the subject matter regarded as the invention. Regarding this rejection, the Office Action indicates that claim 6 recites the limitation "in the first sequence", which lacks proper antecedent basis.

By the present Amendment, Applicants have amended independent claim 6 to recite --in a first sequence-- thereby remedying the lack of antecedent basis. Withdrawal of this rejections is therefore respectfully requested.

V. Rejections under 35 USC §103

Claims 6-12 were rejected under 35 USC §103(a) as being unpatentable over Dodd in view of Wilkening, and further in view of Hunt. Regarding this rejection, the Office Action indicates that Dodd discloses a system that includes a transmit beamformer for supplying high voltage transmit waveforms in a plurality of channels via a TX/RX switch to a transducer array, and that the transmit beamformer and the transducer array have a broadband response and are capable of transmitting the maximum allowable acoustic power densities for better signal to noise sensitivity. The Office Action indicates that Dodd further discloses ultrasonic energy echoed by the subject at the harmonic frequency being received by the transducer array and focused by the receive beamformer, and the focused signal being filtered with a high pass filter and displayed as an image. Dodd is further indicated as disclosing the transmit beamformer with N channels each of which includes a delay memory, a delay counter, and a signal generator. The signal generator generates pulse width modulated transmit waveforms and includes a timing sequencer, a waveform generator, a digital to analog converter. The sequencer controls transmit/receive

sequence of the transit/receive beamformer via time control, and waveforms and signals are summed. The Office Action further indicates that Dodd discloses the duration or width of each pulse within the transmit waveform being varied to reduce energies transmitted at harmonic frequencies, such as the second order harmonic frequencies. The duration corresponds to the beginning and end of the pulse.

The Office Action admits that Dodd fails to disclose controlling a carrier wave to vary in phase by 360 degree/N. Wilkening is relied upon for disclosing a method of transmitting/receiving a sound pressure pulse an N number of times using the transmitted-pulse waveform rotated in steps of 360 degree/N in phase angle. Wilkening is indicated as allowing components up to the (N-1) th-order harmonic component to be removed, and sharply distinguishing between signals of different spectral characteristics by filtering each signal during the summation. The Office Action concludes that it would have been obvious to combine the teachings of Dodd with those of Wilkening for the purpose of increasing signal to noise ratio, and for performing the transmit/receive operation three times or greater to achieve greater overall imaging bandwidth and improved axial resolution. Applicants respectfully disagree.

As amended, independent claim 6 defines an ultrasonic imaging device for transmitting/receiving ultrasonic pulse to/from a living body in which microbubbles for contrast are introduced, and forming a contrast image of the inside of the living body. The ultrasonic imaging device comprises:

> a transmit beamformer for generating a transmit pulse, said transmit beamformer including a D/A converter and a non-linear amplifier;
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> a receive beamformer for generating a time-series reception echo signal with adding receive signals, to each of which a delay time is given for generating receiving sensitivity having directivity;

an adder for summing the time-series reception echo signals; and

a transmit/receive sequence controller for controlling the transmit beamformer and the receive beamformer;

wherein in a first sequence, the transmit/receive sequence controller controls the transmit beamformer and the receive beamformer to perform transmitting/receiving operations N times (N= an integer of three or greater) by controlling a sampling frequency of the transmit pulse being an integer-multiple of 3 with respect to a central frequency of frequency components of the transmit pulse, and N pieces of transmission pulse waves having a common envelope signal and different waveforms under a transmission/reception wave focus condition, and controlling carrier waves of the transmission pulse waves so as to vary in phase by 360°/N from one wave to a next wave, and receiving returned ultrasonic waves as N pieces of the time-series reception echo signals; and

wherein said adder sums the N pieces of the time-series reception echo signals so as to output an output signal as a signal indicative of a spatial distribution of the microbubbles.

The ultrasonic imaging device of independent claim 6 includes a transmit beamformer for generating a transmit pulse, and a receive beamformer for generating time-series reception echo signals, to each of which a delay time is given for generating receiving sensitivity having directivity. The transmit beamformer also includes a D/A converter and a non-linear amplifier. An adder is provided for summing the time-series reception echo signals, while a transmit/receive sequence controller controls the transmit beamformer and the receive beamformer. According to independent claim 6, during the first sequence, the transmit/receive sequence controller controls the transmit beamformer and the receive beamformer to perform transmitting/receiving operations N times, where N is an integer greater than or equal to 3. This is done by controlling a sampling frequency of the transmit pulse being an integer-multiple of 3 with respect to a central frequency of frequency components of the transmit pulse, and N pieces of transmission pulse waves having

a common envelope signal and different waveforms under a transmission/reception wave focus condition, and controlling carrier waves of the transmission pulse waves so as to vary in phase by 360°/N from one wave to a next wave, and receiving returned ultrasonic waves as N pieces of the time-series reception echo signals. Furthermore, the adder sums the N pieces of time-series reception echo signals and outputs a signal indicative of a spatial distribution of the microbubbles.

As set forth in independent claim 6, the sampling frequency of the transmit pulse is an integer-multiple of N with respect to a central frequency of frequency components of the transmit pulse. As discussed in the specification, the present invention uses a region of a high sound pressure that disturbs the constant relationship in phase between the pulse transmission signal carrier and the contrast medium echo. This is achieved by setting the sampling time interval of the pulse transmission waveform supplied to the D/A converter equal to a multiple of 3 of the central frequency. Accordingly, it becomes possible to zero-suppress the summation value of the pulse transmission signals output from three ultrasonic probes each shifted through a phase angle of 120.degree. using the envelope as a common factor. See paragraph [0031] of the published application.

Furthermore, as discussed during the interview, the output of the amplifier will only be linear (i.e., input proportional to output) under theoretical conditions, or through the use complicated circuitry. In practical applications, however, the amplifier will exhibit non-linear characteristics that effect the three-pulse transmission. For example, at 4 and 8 times the sampling frequencies, the output value of the D/A converter varies from pulse to pulse due to the non-linear characteristics of the pulse-transmitting amplifier. Consequently, the D/A converter

does not take the output value exactly as preset. See paragraph [0080] and Figs. 8A and 8C.

The present invention is capable of preventing variations of the output values of the D/A converter even if there is nonlinearity of input/output characteristics of a pulse-transmitting amplifier, for example, in cases where more than three waveforms having different phases are transmitted. More particularly, the D/A converter output uses a sampling frequency six times (for N pulses, as integer-multiple of 3) as great as the central frequency. Accordingly, variations in the output value of the D/A converter do not occur from pulse to pulse despite the non-linearity of the pulse-transmitting amplifier. See paragraph [0081] and Fig. 18B.

The Office Action alleges that the combination of Dodd and Wilkening discloses all of the features recited in independent claim 6. This does not appear to be the case. Dodd discloses an ultrasonic imaging method wherein ultrasonic energy is transmitted at a fundamental frequency and reflected ultrasonic energy is received at a harmonic of the fundamental frequency. The waveform transmitted includes at least a sequence of at least a first and second pulse characterized by first and second pulse durations, respectively, where the second pulse duration is different than the first duration. Dodd only discloses an ultrasonic imaging system using harmonic frequency signals, wherein a sampling frequency F_s is MF_T. Dodd further indicates that M is associated with the number of samples. See column 8, lines 6 - 7. Dodd never discloses or suggests that the sampling frequency of the transmit pulse is an integer-multiple of 3 with respect to a central frequency of the frequency components of the transmit pulse.

As discussed during the interview, Wilkening also fails to disclose such a feature. Rather, Wilkening discloses a theoretical explanation of a method for

transmitting three pulses. There is no disclosure or discussion of components that would be capable of achieving a theoretical linear output. The background section of the application also describes various disadvantages associated with the theoretical explanation disclosed by Wilkening. Additionally, Wilkening is completely silent on controlling the sampling frequency, and in particular, controlling the sampling frequency with respect to the central frequency of the frequency components of the transmit pulse. The combination of Dodd and Wilkening fails to provide any disclosure or suggestion for features recited in independent claim 6, such as:

> wherein in a first sequence, the transmit/receive sequence controller controls the transmit beamformer and the receive beamformer to perform transmitting/receiving operations N times (N= an integer of three or greater) by controlling a sampling frequency of the transmit pulse being an integer-multiple of 3 with respect to a central frequency of frequency components of the transmit pulse, and N pieces of transmission pulse waves having a common envelope signal and different waveforms under a transmission/reception wave focus condition, and controlling carrier waves of the transmission pulse waves so as to vary in phase by 360°/N from one wave to a next wave, and receiving returned ultrasonic waves as N pieces of the time-series reception echo signals; and
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> wherein said adder sums the N pieces of the time-series reception echo signals so as to output an output signal as a signal indicative of a spatial distribution of the microbubbles.

It is therefore respectfully submitted that independent claim 6 is allowable over the art of record.

During the Interview, the Examiner indicated that the specification did not appear to provide adequate support for the "central frequency" as well as the manner in which it is determined for application in the claimed invention. Applicants indicated that the central frequency was a well established value across various fields involving wave transmission/reception, and that supporting references/evidence would be provided to support this position. Applicants are

currently in the process of obtaining such information and will provide it to the Examiner shortly.

Claims 7-12 depend from independent claim 6, and are therefore believed allowable for at least the reasons set forth above with respect to independent claim 6. In addition, these claims each introduce novel elements that independently render them patentable over the art of record.

For the reasons stated above, it is respectfully submitted that all of the pending claims are now in condition for allowance. Therefore, the issuance of a Notice of Allowance is believed in order, and courteously solicited.

If the Examiner believes that there are any matters which can be resolved by way of either a personal or telephone interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

AUTHORIZATION

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 520.46411X00).

Respectfully submitted,
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